2. This epigonium or nucleus is lined by a membranous embryo-sac.

3. The embryo developed in this ovule is represented by the capsule with its pedicel.

4. The nucleus and the embryo-sac are closed at first and open a little before fecundation.

5. The embryo-sac contains a free vesicle which produces the embryo by its development. This embryonal vesicle exists before the opening of the nucleus and consequently before fecundation.

II. *Ricciæ.*—6. In the Ricciæ there exist a nucleus, an embryo-sac, and an embryonal cell exactly like those of the Mosses. This embryonal cell, however, instead of producing a capsule with its pedicel, merely becomes enlarged, and the sporiferous cells are formed immediately in the interior of this membranous sac, which is itself enveloped by the epigonium.

III. *Ferns.*—7. The Ferns have ovules exactly like those of the Mosses and Hepaticæ, also consisting of a nucleus formed of a simple layer of cells and lined internally by an embryo-sac.

8. In the Ferns these ovules are produced on a very simple frond, which is the immediate result of the germination of the spores. The embryo which is formed in these ovules reproduces the original plant, as in the Phanerogamia.

9. The ovule or nucleus of the Ferns is at first closed at the apex and opens for fecundation; it contains before its opening an embryonal cell which produces the embryo by its development.

10. The embryo of the Ferns consists of a primary leaf, a primary root, and a conical base representing the stem or the axis of the plant. The primary root is not a continuation of the stem as in the embryo of the Phanerogamia; it is oblique, and from this character the embryo of the Ferns may be called *plagiorhizal.*

11. This character still exists in the developed plant. Each leaf has its proper root, which separates almost immediately from the stem, and takes an oblique direction towards the earth.

12. In the Ferns, Mosses and Hepaticæ, the base of the embryo is turned towards the base of the ovule, and the apex towards its summit or *micropyle*; so that it is in a position the reverse of that which it occupies in the Phanerogamia.—*Comptes Rendus,* Dec. 13, 1852, p. 851.

MODE OF DETERMINING THE OPTICAL POWER OF A MICROSCOPE. BY PROFESSOR HARTING OF UTRECHT*.

The optical power of a microscope may be said to consist of three qualities, viz. magnifying power, defining power, and penetrating power. Although the first is the quality to which most importance is generally attributed, the practised observer well knows that it is of far less consequence than the second and third. And although there

* Translated by the Editor of the Monthly Journal of Medical Science, from 'Het Mikroskoop,' vol. i. p. 407.

are a variety of simple means by which the magnifying powers of microscopes may be ascertained and compared, it is to be regretted that science has not yet suggested any easy and infallible mode of testing their powers of definition and penetration. *Definition* appears mainly to depend upon the amount of exactitude with which the spherical and chromatic aberrations of various parts of the instrument are balanced and corrected. *Penetration* chiefly depends upon the "angle of aperture" of the object-glass, *i. e.* upon the *angular width* of the luminous pencils passing from each point of the object through the lens. The brightness of the image increases as the square of the diameter of the lens or mirror which produces it; hence it is obvious that of two lenses of equal focal length and refracting power, that which is the wider and can transmit the broader pencil of rays, will give the brighter image. If the effective diameters of two such lenses be =1 and 3, there will be *nine* times as much light in the image formed by the second as in the image formed by the first. Of course there will be, in the image formed by the second lens, parts clearly visible, which in the image formed by the first lens were too feebly illuminated to affect the retina of the observer. When the aberrations are perfectly corrected, *i. e.* when the rays passing from the object through the centre and margins of the lens are refracted without chromatic dispersion and to the same foci, the maximum of defining power is attained, and the penetrating power of the lens is likewise a maximum for that angle of aperture. It does not, however, follow that a lens of greater angular aperture is not superior in penetration, nor that a lens of exquisite penetrating power, *i. e.* capable of exhibiting the most feebly illuminated parts of an image, must necessarily be one of good defining power, *i. e.* capable of exhibiting sharp outlines on bodies of extreme minuteness, or of resolving or separating the dots, stripes, etc., of the more difficult test-objects. With these preliminary observations, which may be regarded as an imperfect abridgement of different chapters in Harting's excellent treatise, we proceed to lay before our readers his very ingenious and beautiful method for testing the qualities of definition and penetrating power.—*Editor.*

I conclude by noticing another method of testing the optical power of the instrument, which, although rather troublesome, appears to me among the best, permitting us, as it does, to ascertain with a great degree of accuracy and certainty, the utmost limits of penetrating and separating power possessed by a microscope, and hence easily to express numerically its optical qualities in the most varied circumstances.

This method consists simply in subjecting to observation under the microscope the dioptric images of certain minute objects instead of the objects themselves. These images can be diminished at pleasure by withdrawing to a distance from the lens the object which forms them; and hence we have it in our power to measure the extreme limits at which the object continues to be visible.

For the formation of the dioptric images, achromatic object-glasses

might be used; but even where those of the shortest focal length are employed, the object whose image it is required to form must be placed at a great distance. This would cause various difficulties, and only be practicable with a microscope placed horizontally—unless, indeed, the object selected were very minute, in which case the accurate determination of its diameter (from which that of its image must be afterwards deduced) would be rendered difficult.

Small air-bells in a fluid are for this purpose far better. I employ by preference a watery solution of powdered gum arabic, which always contains numbers of such air-bells originating in the air entangled among the particles of the powder. The water employed should have stood for a considerable time freely exposed to the air, or been shaken up with air for some time; for when we use water which is not saturated with air, the bubbles in the fluid gradually become smaller, and images formed in them decreasing in magnitude, cause errors in the subsequent measurements, as we shall actually find to be the case.

A drop of the fluid must then be placed on a clean glass object-slide, and covered with a good clear mica plate, a ring-shaped piece of paper being interposed, in order to prevent the flattening of the air-bells by pressure. The object-slide is then placed under the object-glass upon the stage of the microscope, and an air-bell of suitable size for the formation of the images is sought for. All do not give images of the same degree of sharpness; a peculiarity dependent on the fact that some air-bells are in contact with the covering-plate, and consequently have their spherical form disturbed to some extent, or on the presence of small molecules in the fluid above or beneath the air-bell, or even in its interior, causing some haziness of the image, just as defective polish of a glass lens would do. It will, however, be always easy to find some* which will form images of the utmost distinctness and purity. This may be ascertained in the first instance by holding between the mirror and stage some easily recognized object, *e.g.* a piece of paper or the like. The image is always formed on the under surface of the air-bell, which must consequently be brought nearer to the object-glass than when it is desired to bring its margins into focus.

The object whose image is to be the subject of examination should be placed upon an apparatus, which can be moved upwards and downwards in the space between the mirror and the stage. In some microscopes this can hardly be done, either from the space being too limited, or in consequence of the drum-like form of the foot of the microscope which quite envelopes the space. If such microscopes, in

* The following example will demonstrate this. I brought a printed page of a book to such a distance from an air-bell that the length of the image of the whole page was $\frac{1}{7}$th millimetre=about $\frac{1}{180}$th of an inch, and that of the image of each letter about $\frac{1}{480}$th millim.=$\frac{1}{12000}$th of an inch. In spite of their minuteness, these images, formed by reflected light, possessed such clearness and sharpness, that under a magnifying power of 154 diameters, the whole page was, without difficulty, legible.

place of a mirror, be provided with a reflecting prism, the object may be placed opposite the side external to the microscope. The instruments best adapted for the manipulation which we are describing are, however, those whose illuminating apparatus consists of a mirror and converging lens, which can be shifted up or down. The lens being removed from the ring which supports it, the object is substituted in its place. The relative magnitudes of object and air-bell must be such that the image shall be exceedingly minute when the object is tolerably near to the stage. On afterwards increasing the distance between the object and air-bell, it is not difficult to find the limit at which the image (under a given magnifying power) is barely visible.

Of course it is impossible to measure *directly* the dimensions of this most minute visible image, for our best micrometric methods will here be found of no avail. Yet their size may be estimated with extreme accuracy in the following manner. At the same distance from the air-bell and in place of the object used, substitute another body, such as a piece of card, of 4 to 5 centimetres $=1\frac{3}{5}$ths to inches diameter, which has been exactly measured. Let this be now again measured just as if it were a real object. By dividing the real diameter by the apparent diameter, the amount of diminution is found; and this is the same for all objects at a like distance from the air-bell. We have, consequently, nothing to do, in order to find the amount of diminution of the image of the more minute object, but to divide its *true* diameter by the figure expressing the diminishing power.

For example, let the true diameter of the greater object be 5 centimetres =to 1·969 English inch, and the diameter of its image= 32·2 micromillimetres*, =·00127 English inch, then the figure expressing the amount of diminution will be $\cdot\frac{1\cdot969}{00127}=1553$ very nearly. If now the smaller object have a diameter of 175 micromillimetres =·00689 English inch, then must its image at the limit of vision be in diameter $=\cdot\frac{00689}{1553}=$·0000044, or about $\frac{1}{225,000}$th of an English inch. When exact micrometric methods are employed, it is easy in this way to estimate the diameter of an image even to millionth parts of a millimetre, *i. e.* to 25,400,000th parts of an inch.

As for the object suitable for these investigations, it is plain that we have an extensive choice. To find the limit of vision for bodies of a round or long thread-like form, grains of pearl sago, or vegetable bodies, such as mustard-seed or the pollen-granules of many plants, hairs of animals, metallic wires, &c., may be employed. Small round openings and chinks may serve for the determination of the visibility of positive images of light. In the last case care must of course be taken, by means of suitable screens, to shut off all light except what passes through the aperture. To determine the defining power, metallic wire-gauze is a suitable object, or two holes placed near each other in a black metallic plate. The images of such objects resemble exactly a double star viewed through a telescope (*kijker*). The bodies may likewise be placed in different circumstances in order to

* The micromillimetre is equal $\frac{1}{1000}$ millimetres=·0000394 English inch.

ascertain the influence of these upon the limits of vision. Thus we may use as an object a very thin glass capillary tube placed in water, and compare it with tender organic tubes and vessels, which may also be seen in water, but whose limit of visibility is of course far more circumscribed than that of absolutely opake objects.

In fact this method admits of innumerable variations, and is consequently of most extensive application. Besides, when proper precautions are taken, it gives results perfectly sure and comparable. Especial care is, however, requisite in the mode of illumination. For it is certain, that when the field has a clear white ground, the contrast causes minute opake bodies (*i. e.* objects which are dark by transmitted light) to continue visible, which against a grayish or light-blue back-ground could not be seen. Hence it is by no means indifferent to receive on the mirror light from a white cloud, from a dull overcast, or clear blue sky. Artificial light cannot be used in these experiments, for the image of the flame becomes diminished like the object, and hence a clear field of view is not to be obtained. The observations must consequently be made by daylight; and whenever comparable results are sought for, the mirror should always be directed to the clear, blue, cloudless sky—this being a distinct atmospheric condition to which others in similar circumstances may refer in conducting the same experiment. The mode of ascertaining the limit of vision, with a given amount of illumination, may be gathered from different examples in the body of this work*. It will likewise be found that for all such observations, even when the highest magnifying powers are employed, the *flat* mirror is perfectly sufficient, since in the image in the field of view formed by the air-bell, all the rays proceeding from the mirror are united and constitute an object of considerable luminous intensity.—*Monthly Journal of Medical Science*, April 1853.

MARINE VIVARIA.

To the Editors of the Annals of Natural History.

Weymouth, May 24, 1853.

Gentlemen,—With reference to plants for Marine Vivaria I have to state, that some species, if not all, do equally well without their roots being attached. On the 4th of May I placed a few mollusks in a glass 8 inches in height and 4 across; I also placed in it a plant of *Rhodymenia palmata*, but which had no root attached; I therefore attached it by means of a thread to a small piece of stone in order to keep the plant erect. This plant alone has supplied the water with oxygen to this day, and appears as healthy as the day it was put in, now three weeks since. The animals are alive and the water has not been changed.

I am, Gentlemen, yours obediently,
William Thompson.

* It is unnecessary to introduce any examples here, the author's description of his method being both full and suggestive.—Editor.